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Age calibration of megafossil biochronology based on Early Campanian planktonic foraminifera from Hokkaido, Japan

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Abstract. **The occurrence of an Early Campanian planktonic foraminiferal assemblage consisting of *Globotruncana arca*, *G. linneiana*, *Rosita fornicata* and *R. patelliformis* is first reported from the Upper Haborogawa Formation exposed in the Haboro area, northwestern Hokkaido, Japan. This finding supports the previous interpretation that the Santonian/Campanian boundary can be placed at the basal part of *Inoceramus* (*Platyceramus*) *japonicus* Zone of the inoceramid biostratigraphy.**

Key words: biostratigraphy, Hokkaido, planktonic foraminifera, Santonian/Campanian boundary

Introduction

The Late Cretaceous ammonoid and inoceramid zonal schemes in Japan have been progressively improved by several recent biostratigraphic studies (e.g. Toshimitsu and Maiya, 1986; Toshimitsu *et al.*, 1995a, b; Toshimitsu *et al.*, 1998). Five standard inoceramid zones, i.e. *Inoceramus* (*I.*) *uwajimensis*, *I.* (*I.*) *mihoensis*, *I.* (*I.*) *amakusensis*, *I.* (*Platyceramus*) *japonicus* and *Sphenoceramus schmidti* - *S. orientalis* in ascending order have been proposed by Toshimitsu *et al.* (1995b) for the Coniacian to middle Campanian sequence in the Haboro area, northwestern Hokkaido.

The megafossil assemblages in northwestern Hokkaido, however, lack frequently the Tethyan zonal markers, particularly during the Santonian to Maastrichtian intervals. This scarcity of marker species causes the international correlation difficult between the Tethyan and the Northwestern Pacific bioprovinces including Japan.

We here report the occurrence of the Tethyan planktonic foraminiferal species *Rosita patelliformis* (Gandolfi) from the Cretaceous Upper Yezo Group in the Haboro area and discuss age calibration of megafossil biochronology.

Geological setting and lithostratigraphy

The Upper Cretaceous strata exposed in the Haboro area are lithostratigraphically divided into three units, namely the Middle Yezo, Upper Yezo, and Hakobuchi Groups in ascending order (Figure 1). The Middle Yezo Group is composed of the Shirochi Formation. The Upper Yezo Group is subdivided into the Lower, Middle and Upper Haborogawa Formations. The Hakobuchi Group consists of the Pankezawa Formation. The Shirochi Formation is composed of alternating beds of sandstone and mudstone, and the Lower and Middle Haborogawa Formations consist of mudstone. The Upper Haborogawa Formation is characterized by two coarsening upward sequences, each of which begins with mudstones, graded to bioturbated muddy sandstones and ends with thick-bedded sandstones (Moriya and Hirano, 2001). The Pankezawa Formation is mainly composed of sandstone.

As concerns the Upper Haborogawa Formation in the study area (Figures 1, 2), the thickness of the first sequence is about 550 m, while the second one is approximately about 530 m. The mudstones in the lower part of the first sequence are intercalated with 4 to 5 cm thick, medium-bedded, fine- to medium-grained sandstones (Figure 3). The sandstone intercalations tend to be more frequent toward the top of the sequence. The uppermost part of the sequence represents a 10 m thick sandstone unit, named UHs1 (Toshimitsu, 1985), which is pale-green-colored, parallel- and cross-laminated, frequently interbedded with thin mudstone of a few cm thick (Figure 3). This unit can be traced laterally as a marker horizon in the investigated area (Figure 2). The weakly laminated mudstones of the second

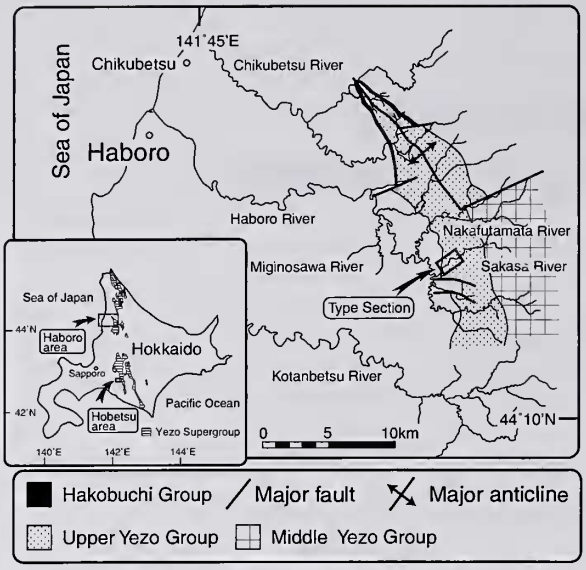


Figure 1. Index map and geological outline of the study area. The rectangle shows the investigated area where the type section of the Upper Haborogawa Formation is exposed.

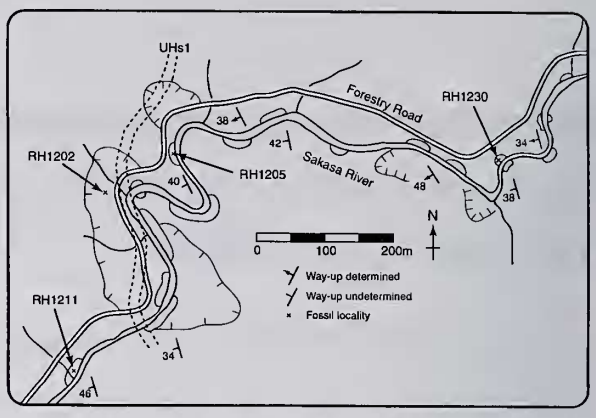


Figure 2. Route map of the type section of the Upper Haborogawa Formation along the Sakasa River in the Haboro area, showing the mega- and microfossil localities. For RH numbers, refer Toshimitsu (1985).

cycle overlie the unit UHs1, but the upper part of this cycle is not exposed in the investigated section (Figures 2, 3).

Material and methods

We collected three sediment samples from mudstones or sandy mudstones of the upper part of the Upper Haborogawa Formation at locs. RH1202 (along the Sakasagawa Forestry Road in the Haboro area), RH2530 and RH2531 (along the Nakafutamata River) (for RH1202 refer Figures 2, 3; for RH2530 and 2531 refer Toshimitsu, 1985, fig. 5a).

In a laboratory, each sample, 1.5 kg in weight was disaggregated with hydrogen peroxide and sodium tetraphenylborate (Hanken, 1979) to extract foraminiferal specimens. The disaggregated residues were washed using 75 μm sieve. All specimens larger than 125 μm were identified. The illustrated planktonic foraminifera (Figure 4) yielded from loc. RH1202 are housed in the University Museum of the University of Tokyo (UMUT).

Planktonic foraminiferal assemblages

The following species were recognized from the upper

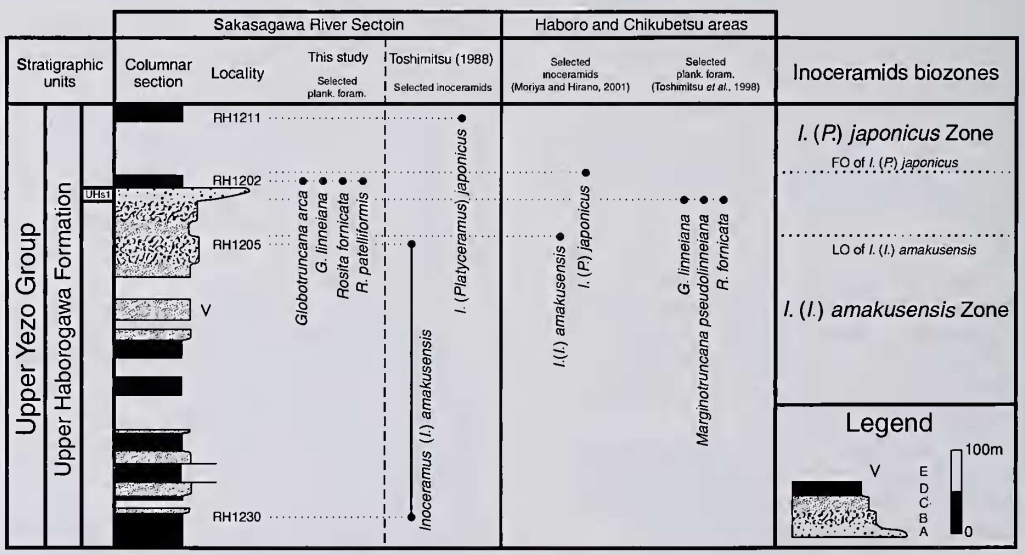


Figure 3. Biostratigraphic summary of selected mega- and microfossils in the Upper Haborogawa Formation along the Sakasa River and adjacent areas. The stratigraphic horizons of bioevents are compiled from Toshimitsu (1988), Toshimitsu *et al.* (1998) and Moriya and Hirano (2001; Chikubetsu area). A, sandstone; B, muddy sandstone; C, sandy mudstone; D, mudstone; E, acidic tuff.

Table 1. List and the number of specimens of the planktonic foraminiferal specimens occurred from the upper part of the Upper Haborogawa Formation. For the localities of RH2530 and RH2531, see Toshimitsu (1985, fig. 5a).

Species	Locality		
	RH 2531	RH 2530	RH 1202
Archaeoglobigerina blowi		17	
A. bosquensis		14	
A. cretacea		8	1
Dicarinella sp.		3	
Globigerinelloides asper		3	
Globotruncana arca		6	4
Globo. cf. *arca*		10	
Globo. bulloides		40	15
Globo. lapparenti			1
Globo. linneiana	16	125	38
Hedbergella aff. *planispira*	1		
Heterohelix reussi		1	
Marginotruncana pseudolinneiana	1	9	
Rosita fornicata		8	1
Rosita patelliformis			1

part of the Upper Haborogawa Formation: *Archaeoglobigerina blowi* Pessagno, *A. bosquensis* Pessagno, *A. cretacea* (d'Orbigny), *Dicarinella* sp., *Globigerinelloides asper* (Ehrenberg), *Globotruncana arca* (Cushman), *Globo. bulloides* Vogler, *Globo. lapparenti* Brotzen, *Globo. linneiana* (d'Orbigny), *Hedbergella* aff. *planispira* (Tappan), *Heterohelix reussi* (Cushman), *Marginotruncana pseudolinneiana* Pessagno, *Rosita fornicata* (Plummer), and *R. patelliformis* (Table 1). In the assemblages, *Globotruncana linneiana* is the most abundant species at all localities, and *Globotruncana bulloides* is subordinate at locs. RH1202 and 2530. The mudstone sample from loc. RH1202 yielded a total of 61 well-preserved specimens of planktonic foraminifers. Some of them identified as *Globotruncana arca*, *G. linneiana*, *Rosita fornicata*, and *R. patelliformis*, are shown in Figure 4. Among the assemblage, *R. patelliformis* is represented by a single specimen (Table 1), but this is the first report of the species from Japan. This specimen is not so large, having a circular peripheral outline and less convex spiral (Figure 4.1). Although the last chamber is somewhat deformed, chambers in the final whorl are crescentic and narrow, and the surface of the test is not so undulated. Judging from these characters, the specimen is undoubtedly identified as *R. patelliformis*.

Correlation

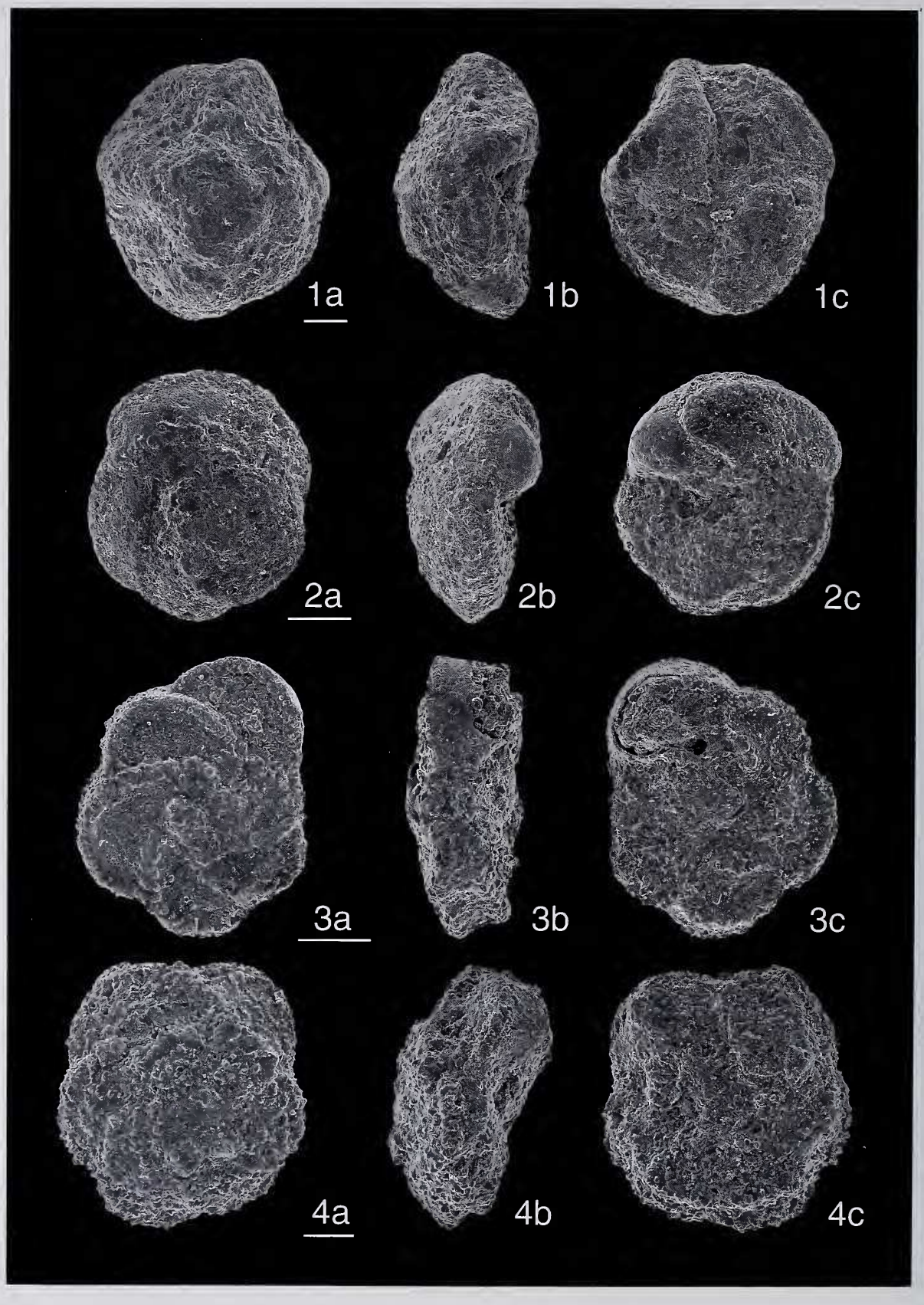
Sliter (1989) proposed a scheme of Cretaceous planktonic foraminiferal biostratigraphy, showing the stratigraphic ranges of selected species. The planktonic foraminiferal zonation applied here is based on that study. The first occurrence (FO) of *R. fornicata* is placed closed to the Coniacian/Santonian boundary. Although there are a few objections for the age of FO of *Globotruncana arca* (Kopaevich and Salaj *in* Hancock and Gale, 1996), *G. arca* and *G. linneiana* should appear within the uppermost Santonian *Dicarinella asymetrica* Zone (Caron, 1985; Sliter, 1989). The FO of *R. patelliformis* is placed within the *Globotruncanita elevata* Zone of the upper part of the Lower Campanian. The assemblage from the mudstone sample at loc. RH1202 is, therefore, assigned an age of Early Campanian, probably the *G. elevata* Zone.

Discussion

Inoceramus (*Inoceramus*) *amakusensis* Nagao and Matsumoto was obtained from bioturbated muddy sandstones at locs. RH1205 and RH1230 (Toshimitsu, 1985; Figures 2, 3). *I.* (*Platyceramus*) *japonicus* Nagao and Matsumoto occurs from the mudstones above the UHs1 sandstones (Toshimitsu, 1988; loc. RH 1211 in Figures 2, 3). The last occurrence (LO) of *I* (*I.*) *amakusensis* is recognized at about 50 m below the unit UHs1, whereas *I.* (*P.*) *japonicus* first appears at about 20 m above UHs1 (Toshimitsu, 1998; Moriya and Hirano, 2001). Hence, the Upper Haborogawa Formation can be biosratigraphically divided into the *I.* (*I.*) *amakusensis* and *I.* (*P.*) *japonicus* Zones, with a boundary within the UHs1 sandstones (Figure 3).

Toshimitsu *et al.* (1998) defined the Santonian/Campanian boundary by the FOs of the ammonoid *Submortoniceras* cf. *condamyi* (Collignon) and a planktonic foraminifer *Globotruncana arca* in the Haboro area, and placed the boundary just above the UHs1 of the Upper Haborogawa Formation.

Hancock (1991) initially stated that the FO of *Submortoniceras* might coincide with the Santonian/Campanian boundary. The evolution of *Submortoniceras* from *Texanites* was, however, later inferred to have occurred during the late Santonian (Gale *et al.*, 1995; Hancock and Gale, 1996). Furthermore, although Kopaevich and Salaj (*in* Hancock and


1a
1b
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Gale, 1996) emphasized that the "*G. arca*" which occurred from the Upper Santonian is an ancestral form of the true "*G. arca*", the FO of *G. arca* should be placed within the upper Santonian *D. asymetrica* Zone (e.g., Caron, 1985; Sliter, 1989; Hancock and Gale, 1996). Therefore, the FOs of *Submortoniceras* and *G. arca* are inappropriate as the boundary markers, and these bioevents have not been adopted as Santonian/Campanian boundary criteria (Hancock and Gale, 1996).

We found an Early Campanian planktonic foraminiferal assemblage consisting of *Globotruncana arca*, *G. linneiana*, *Rosita fornicata* and *R. patelliformis* from just above the unit UHs1 of the upper part of the Upper Haborogawa Formation in the Haboro area (Figures 2, 33; loc. RH1202 along the Sakasagawa Forestry Road in the Haboro area). Toshimitsu *et al.* (1998) found a Late Santonian planktonic foraminiferal assemblage consisting of *Globotruncana linneiana*, *Marginotruncana pseudolinneiana* and *Rosita fornicata* from mudstones just below the UHs1 unit along the Miginosawa Creek. Toshimitsu *et al.* (1998) also described the occurrence of *Globigerinelloides prairiehillensis* Pessagno from about 200 m above the UHs1 unit along the Kotanbetsu River. Therefore, in the Haboro area, the Santonian/Campanian boundary can be temporally placed at the top of the unit UHs1.

This level is very close to the boundary between the *Inoceramus* (*I.*) *amakusensis* Zone and the *I.* (*Platyceramus*) *japonicus* Zone of the inoceramid biostratigraphy (Figure 3). Toshimitsu *et al.* (1998) expected to place the Santonian/Campanian boundary at the basal part of the *I.* (*P.*) *japonicus* Zone and our finding substantiates this idea.

The K-Ar dating, furthermore, revealed that in the Horosari-zawa section of the Hobetsu area, a white acid tuff intercalated with mudstones of the lower part of the *I.* (*P.*) *japonicus* Zone is dated at 82.2 ± 0.6 Ma (Shibata and Uchiumi, 1995; Toshimitsu *et al.*, 1998). The K-Ar age supports the idea that the age of the *I.* (*P.*) *japonicus* Zone is Early Campanian.

Concluding remarks

In this paper, we have reported the FO of *Rosita patelliformis* at about 10 m above the sandstone beds UHs1 (Figures 2, 3; loc. RH1202 along the Sakasagawa Forestry Road in the Haboro area). Our new finding of this planktonic foraminifera suggests that the Santonian/Campanian boundary should be drawn around the horizon of the sandstone beds UHs1, probably close to the boundary between the *I. amakusensis* and *I.* (*P.*) *japonicus* Zones as proposed by Toshimitsu *et al.* (1998).

Hancock and Gale (1996) proposed the following Santonian/Campanian boundary criteria: (1) the lowest occurrence of the ammonoid *Placenticeras bidorsatum* (Roemer), (2) the extinction level of the crinoid *Marsupites testudinarius* (Schlotheim), (3) the extinction in the planktonic foraminifers of *Dicarinella concavata* group, (4) the first occurrence (FO) of nannofossil *Broinsonia parca* (Stradner), and (5) the basal part of the paleomagnetic the Chron C33r. To set the Santonian/Campanian boundary precisely in Japan, we need to inspect these boundary criteria for further study.

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← **Figure 4**. Planktonic foraminifera from the loc. RH1202 along the Sakasagawa forestry road in the Haboro area. **1a-c.** *Rosita patelliformis* (Gandolfi), UMUT MF 27977. **2a-c.** *Rosita fornicata* (Plummer), UMUT MF 27978. **3a-c.** *Globotruncana linneiana* (dOrbigny), UMUT MF 27979. **4a-c.** *Globotruncana arca* Cushman, UMUT MF 27980. 1-3, Scale bars are 100 μm; 4, Scale bar is 50 μm.

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